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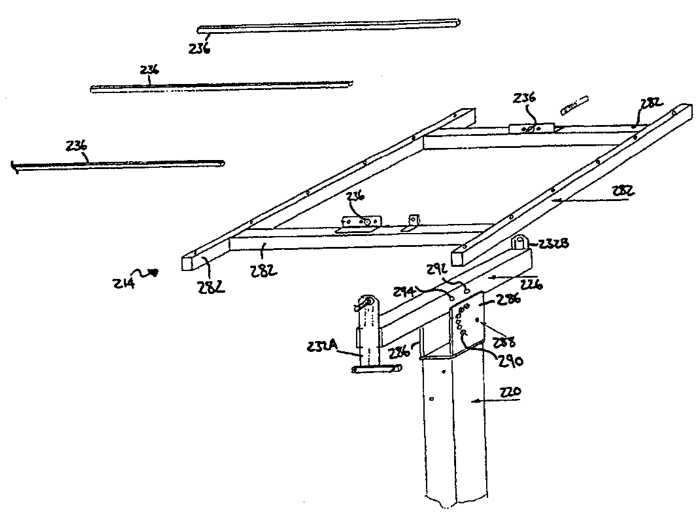
**(54) Title:** ASSEMBLY FOR SOLAR PANELS




**(57) Abstract**

An assembly for solar panels is described, comprising a base and a frame for receiving solar panels pivotally mounted to the base. A light sensor is mounted to the frame or to a solar panel to produce a sensor signal indicative of the ambient light conditions. A linear actuator extends between the frame and the base to rotate the frame in response to a control signal from a controller so that the frame tracks the daily movement of the sun. The controller is programmed to produce a control signal to position the frame in a substantially horizontal position if the sensor signal indicates light conditions below a threshold level. The sensor signal must indicate a change in the position of the frame is required for a prescribed time before the controller will produce an appropriate control signal, which prevents power wastage resulting from temporary changes in the ambient light conditions, such as a cloud passing overhead.

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## TITLE

"Assembly For Solar Panels"

## FIELD OF THE INVENTION

This invention relates to an assembly for solar panels, and in particular, to an assembly for tracking the daily movement of the sun to improve the collection efficiency of the solar panels. The assembly also has utility in other applications where it is desired to track the movement of the sun.

## BACKGROUND ART

Photovoltaic arrays, otherwise known as solar panels or solar cells, are known for their ability to produce energy without environmentally damaging by-products. Solar panels are also well suited for use in remote locations, where mains power is not available.

For maximum efficiency, the solar panels should be directly facing the sun. If the solar panels directly face the sun during the course of a day, they can provide approximately 35% more energy than panels held in a fixed position. Accordingly, it is desirable for the solar panels to be mounted to an assembly that tracts the position of the sun to obtain maximum efficiency. Two types of tracking are possible, tracking of the daily movement of the sun and tracking the seasonal movement of the sun. The first of these provides the greatest increase in efficiency.

US Patent 4,832,001 to Baer describes a light weight support for one or more solar panels in which a pair of hollow cylinders filled with Freon gas. One cylinder is provided to each end of the solar panel. Each of the cylinders are partially shaded so that as the sun rotates, the cylinders receive different amounts of sun. The cylinders are interconnected. The flow of Freon between the cylinders as the sun heats the cylinders ensures the panels rotate to face the sun. Such a system has the advantage of being relatively low maintenance and simple. However, the

Freon gas used is a chlorofluorocarbon (CFC), which has been known to cause damage to the ozone layer. Accordingly, such systems are no longer usable in many countries because of the restrictions on the use of CFC's.

Us Patent 4,890,599 to Eiden discloses a solar tracking control system having a frame mounted on a support shaft. The frame rotates to track the daily movement of the sun based on a fixed timer that energises a motor. As azimuthal tracking of the sun throughout the year is provided with means of a series of bolt holes requiring manual adjustment. The use of the fixed timer introduces their requirement of synchronization between the timer and the movement of the sun. The solar tracking system described by Eiden mounts the frame and solar panels directly on the output shaft of a motor. Accordingly, the motor needs to be able to maintain the position of the frame and weight of the solar panels against the influences of gravity and buffeting winds. Further, the frame and solar panels are all provided spaced in one direction from the output shaft of the motor, creating a torque on the motor. The motor therefore may need to be over-engineered to withstand these forces, resulting in an increase in the cost of the solar tracking systems.

US Patent 4,031,385 to Zerlaut et al describes a solar tracking system which uses a pair of light sensors to provide a differential signal that indicates whether the solar panels are directly facing the sun or not. A fixed timer is also provided as an override in the event that the light sensors attempt to track another object as the brightest in the sky, such as during periods of partial cloud cover. Using light sensors has the advantage of eliminating the need for synchronization between the solar tracking system and movement of the sun, since synchronization is automatically based on the light received form the sun. The frame and solar panel used in the solar tracking system described by Zerlaut et al are rotated directly by an electric motor. Again the frame and solar panels are all provided spaced in one direction from the access of the output shaft of the motor. Accordingly, the motor needs to be able to withstand the weight of the frame and solar panels as well as any buffeting forces from wind. Consequently, the electric motor may need to be over-engineered in similar manner to that described above in relation to the Eiden reference.

## DISCLOSURE OF THE INVENTION

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

An assembly for solar panels, comprising:

a base and a frame for receiving solar panels pivotally mounted to the base;

light sensor means mounted to the frame or to a solar panel thereon and arranged to produce a sensor signal;

means for rotating the frame with respect to the base in response to a control signal; and

control means comprising processor means and memory storing instructions and data, the processor means responsive to the instructions, data and the sensor signal to produce the control signal.

Preferably, the processor means is arranged to produce a control signal to position the frame in a substantially horizontal position if the sensor signal indicates light conditions below a threshold level.

Preferably, the processor means is arranged to delay, for a predetermined time, producing a control signal in response to the sensor signal indicating a change in the position of the frame is required, and if the sensor signal stops indicating the change in position is required during the predetermined time, the processor means does not produce the control signal.

Preferably, the base comprises a cross member pivotally mounted to a support member, the frame being pivotally mounted to the cross member, the frame and the cross member being pivotable about substantially perpendicular axes.

Preferably, the means for rotating the frame comprises an actuator extending between the cross member and the frame.

Preferably, the assembly further comprises damper means extending between the cross member and the frame.

Preferably, the assembly further comprises bearing means provided between the frame and the cross member, wherein a portion of the frame extends to an opposite side of the bearing to act as a counterweight.

Preferably, the bearing means are provided beneath the solar panels.

Preferably, the assembly further comprises a battery for providing power to the control means and the means for rotating the frame, the control means further comprising a circuit for recharging the battery from the solar panels.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its advantages will be better understood with reference to the following description of three embodiments thereof and the accompanying drawings, in which:

Figure 1 is an exploded perspective view of an assembly for solar panels in accordance with a first embodiment of the invention;

Figure 2 is a perspective view of the assembly for solar panels shown in Figure 1;

Figure 3 is an enlarged view of the bearing used in the assembly for solar panels shown in Figure 1;

Figure 4 is a schematic circuit diagram of a controller used in the assembly for solar panels shown in Figure 1;

Figure 5 is a schematic circuit diagram of a battery charger used in the assembly for solar panels shown in Figure 1;

Figure 6 is a flow chart of the operation of the controller shown in Figure 4;

Figure 7 is an exploded perspective view of an assembly for solar panels in accordance with a second embodiment of the invention;

Figure 8 is a perspective view of the assembly for solar panels shown in Figure 7; and

Figure 9 is an exploded perspective view of an assembly for solar panels in accordance with a third embodiment of the invention.

## BEST MODE(S) FOR CARRYING OUT THE INVENTION

The first embodiment is directed towards an assembly for solar panels and is shown in Figures 1-6.

As shown, the assembly 10 comprises a base 12, a frame 14 pivotally mounted to the base 12 for receiving solar panels 15, a linear actuator 16 for rotating the frame 14 relative to the base 12, and a controller 18.

The base 12 comprises a support post 20 secured into the ground (not shown) by suitable means, such as a bed of concrete. A cap 22 having a tubular section 24 extending transversely atop it is provided on the support post 20. A bolt 24a is provided to engage a threaded aperture 24b and then the support post 20 to prevent relative rotation between the cap 22 and the support post 20.

The base 12 further comprises a cross-member 26, which has a pair of flanges 28 provided on opposing sides of the cross-member 26. The flanges 28 are provided mid way along the cross-member 26. Each of the flanges 28 has three apertures 30 provided therein which form the vertices of an equilateral triangle. The apertures 30 in the flanges 28 are aligned. The flanges 28 fit over the ends of the tubular section 24 so that bolts (not shown) passing through the aligned apertures 30 extend through the tubular section 24. By tightening the bolts, the cross-member 26 is secured to the cap 22 and the support post 20.

The cross-member 26 is preferably oriented north-south. Conveniently, by loosening the bolts in the apertures 28, the cross-member 26 (and hence the frame 14 and solar panels 15) can be rotated about the cap 22 to compensate for the seasonal azimuthal changes in the sun's path.

Each end of the cross-member 26 has a bracket 32a and 32b provided thereon. The brackets 32a and 32b extend above the cross-member 26 when the cross-member 26 is positioned on the cap 22. The bracket 32a also extends below the cross-member 26.

The frame 14 comprises two rafters 34 in the form of 90° angle iron with a pair of stringers 36 extending between the rafters 34 in a spaced apart manner. The solar panels 15 are mounted to the stringers 36.

The frame 14 is pivotally mounted to the upper ends of the brackets 32a and 32b via bearings 38. Each bearing 38 includes a flange 40 which is fixed to a corresponding rafter 34 such that the bearings 38 are spaced above the rafters 34. Figure 3 shows this arrangement in detail. The bearings 38 are fixed inwardly of the rafters 34, such that when the solar panels 15 are mounted to the stringers 36 the bearings 38 are beneath them. This provides some shelter to the bearings 38 from the weather, prolonging their life.

The rafters 34 act as a counterweight to the weight of the solar panels 15. The counterweight effect assists in rotation of the frame 14 and solar panels 15 about the bearings 38, in turn reducing the requirements on the linear actuator 16.

The linear actuator 16 extends between the lower end of the bracket 32a and the corresponding rafter 34. Extending and contracting the linear actuator 16 effects rotation of the frame 14 and solar panels 15 about the bearings 38.

The assembly 10 further comprises a sensor 40 mounted on the solar panels 15 at an end thereof. The sensor 40 includes two light sensitive devices 42 provided on opposite sides of the sensor 40. The sensor 40 is arranged so that when the solar panels 15 are directly facing the sun, the light sensitive devices 42 are

perpendicular to the sun. Consequently both light sensitive devices 42 will receive an equal amount of light. As the sun moves during the day, one of the light sensitive devices 42 will receive more light than the other and produce a signal accordingly. The signals from the light sensitive devices 42 form a sensor signal and are input to the controller 18.

The controller 18 is mounted to the cap 22. Figures 4 and 5 show schematic circuit diagrams of the controller 18. The controller 18 comprises a microprocessor 44 and associated bias circuitry denoted generally at 46. The microprocessor 44 in the embodiment is a 60HC705 manufactured by Motorola, Inc. The microprocessor includes an integral programmable memory.

The controller 18 further comprises an input circuit 48, power regulating circuit 50, actuator control circuit 52 and pump control circuit 54.

The input circuit 48 provides power to the sensor 40 and three inputs to the microprocessor 44: the signal from the first light sensitive device 42, the signal from the second light sensitive device 42, and the average of these two signals.

The power regulating circuit 50 provides a regulated +5V supply to the microprocessor 44 using the 7805 power regulator integrated circuit.

The actuator control circuit 52 selectively provides power to the linear actuator 16 in either polarity, under the control of the microprocessor 44. Thus the microprocessor 44 has control over whether the linear actuator 16 expands or contracts.

The pump control circuit 54 selectively provides power to a piston pump (not shown) to enable water to be pumped using power from the solar panels 15. It should be appreciated that this is not the only application of the assembly 10, and the power from the solar panels 15 can be put to other uses with equal efficacy.

The controller 18 further comprises a battery charging circuit 56 shown in Figure 5. The battery charging circuit 56 recharges a battery (not shown) that provides

power to the controller 18, so that operation of the assembly can continue during low light conditions.

Figure 6 is a flowchart showing the operation of the microprocessor 44 in controlling the rotation of the frame 14. If the sensor signals are equal, within a predefined tolerance, the microprocessor 44 is in a 'light level even' state shown at 60. This is the desired condition, since the solar panels will be directly facing the sun.

If the sensor signals become unequal by an amount exceeding the predefined tolerance, the microprocessor 44 enters 'light level uneven' state shown at 62. The microprocessor 44 compares the signals from the sensor 40 and determines which light sensitive device 42 is receiving the most light. From the comparison, the microprocessor 44 determines whether to enter the 'more light east' state shown at 64 or the 'more light west' state shown at 66.

Once in the 'more light east' state 64, the microprocessor 44 continues to monitor the sensor signals for thirty seconds at 68. If the sensor signals return to being equal, indicating the solar panels 15 are still directly facing the sun, the microprocessor 44 returns to the 'light level even' state 60. If the sensor signals continue to be unequal for thirty seconds, indicating the solar panels 15 are no longer directly facing the sun, the microprocessor 44 enters a 'move to the east' state shown at 70. The thirty second delay prevents the waste of power by rotating the frame in response to transient changes in ambient light conditions, such as a cloud passing overhead, or a shadow cast on one of the light sensitive devices 42 from a bird or plane passing overhead.

Similarly, when the microprocessor 44 enters the 'more light east' state 66, the microprocessor 44 continues to monitor the sensor signals for thirty seconds at 72. If the sensor signals return to being equal, indicating the solar panels 15 are still directly facing the sun, the microprocessor 44 returns to the 'light level even' state 60. If the sensor signals continue to be unequal for thirty seconds, indicating the solar panels 15 are no longer directly facing the sun, the microprocessor 44 enters a 'move to the west' state shown at 74.

In the 'move to the east' state 70 or the 'move to the west' state 74, the microprocessor 44 generates a control signal to provide power to the linear actuator 16 via the actuator control circuit 52. The microprocessor 44 continues to provide power to the linear actuator 16 until the sensor signals return to being equal. The microprocessor 44 then returns to the 'light level equal' state 60. the difference between the 'move to the east' state 70 or the 'move to the west' state 74 is in the control signal generated by the microprocessor 44, which controls the polarity of the power provided to the linear actuator 16 according to the desired direction of rotation.

If the sensor signals indicate that ambient light levels are below a threshold level, the microprocessor 44 enters a 'low light level' state shown at 76. It is preferred that the threshold level is set so that the microprocessor 44 will enter the 'low light level' state 76 during a storm as well as at dusk. In the 'low light level' state 76, the microprocessor 44 determines the current position of the frame 14 based on the previous control signals used to rotate the frame 14. The microprocessor 44 then enter a 'return to flat position' state shown at 78.

In the 'return to flat position' state 78, the microprocessor 44 generates a control signal to provide power to the linear actuator 16 via the actuator control circuit 52. The polarity of the power and the duration that the power is applied is dependent upon the position of the frame 14 determined by the microprocessor 44 in the 'low light level' state 76. Power is supplied to the linear actuator 16 to move the frame to a substantially horizontal position.

It should be noted that the frame 14 may not be precisely horizontal because of the azimuthal rotation provided by the flanges 28 about the cap22. However, the frame 14 is positioned so that, if the azimuthal rotation was set to mid way between the horizon, the frame 14 would be horizontal. This position corresponds to the least resistance profile of the assembly 10 to winds. Accordingly it is advantageous that the controller 18 automatically moves the frame 14 to the substantially horizontal position in low light conditions to minimise the likelihood of damage from strong winds in storms.

Once the frame 14 is moved to the substantially horizontal position, the microprocessor 44 monitors the sensor signals. When the sensor signals indicate ambient light above the threshold level, the microprocessor 44 enters the 'light level uneven' state 62 described above and returns to tracking the motion of the sun.

The second embodiment is shown in Figures 7 and 8. Like reference numerals are used to denote like parts to those in the first embodiment, with 100 added thereto. The second embodiment is similar to the first embodiment, however the frame 114 of the second embodiment is elongated to receive more solar panels 115. A damper 180, such as a steering damper used in automobiles, is provided between the bracket 132a and the rafter 134 to reduce vibrations on the frame 114 from wind.

The third embodiment is shown in Figure 9. Like reference numerals are used to denote like parts to those in the first embodiment, with 200 added thereto. The third embodiment is similar to the first embodiment, however the frame 214 of the third embodiment is larger and made from four tube sections 282. The third embodiment is able to receive more solar panels 215 than the first two embodiments.

The bearings 238 are provided above the tube sections 282, hence the tube sections 282 act as counterweights to the weight of the solar panels (not shown). A damper 280 is provided between the bracket 232a and one of the tube sections 282 to reduce vibrations on the frame 214 from wind.

Further, the cap used in the first two embodiments is replaced with two flanges 286 provided atop the support post 220. The flanges 286 have a first aperture 288 and a plurality of second apertures 290 provided in an arc spaced from the first aperture 288. The cross member 226 of the third embodiment is not provided with flanges, instead having two apertures 292 and 294. The cross member 226 is pivotally mounted to the support post 220 by a bolt (not shown) passing through the first aperture 288 in the flanges 286 and the aperture 292. Azimuthal adjustment of the frame 214 can be made by adjusting which of the second

aperture 290 a further bolt (not shown) is passed through. The further bolt also passes through the aperture 294 of the cross member 226.

It should be appreciated that this invention is not limited to the particular embodiments described above.

For example, a further actuator could be provided to rotate the cross-member about the cap with appropriate modifications to the pivotal connection between the cross-member and the cap.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

1. An assembly for solar panels, comprising:

a base and a frame for receiving solar panels pivotally mounted to the base;

light sensor means mounted to the frame or to a solar panel thereon and arranged to produce a sensor signal;

means for rotating the frame with respect to the base in response to a control signal; and

control means comprising processor means and memory storing instructions and data, the processor means responsive to the instructions, data and the sensor signal to produce the control signal.

2. An assembly for solar panels as claimed in claim 1, wherein the processor means is arranged to produce a control signal to position the frame in a substantially horizontal position if the sensor signal indicates light conditions below a threshold level.

3. An assembly for solar panels as claimed in claim 1 or 2, wherein the processor means is arranged to delay, for a predetermined time, producing a control signal in response to the sensor signal indicating a change in the position of the frame is required, and if the sensor signal stops indicating the change in position is required during the predetermined time, the processor means does not produce the control signal.

4. An assembly for solar panels as claimed in any one of the preceding claims, wherein the base comprises a cross member pivotally mounted to a support member, the frame being pivotally mounted to the cross member, the frame and the cross member being pivotable about substantially perpendicular axes.

5. An assembly for solar panels as claimed in claim 4, wherein the means for rotating the frame comprises an actuator extending between the cross member and the frame.

6. An assembly for solar panels as claimed in claim 4 or 5, further comprising damper means extending between the cross member and the frame.

7. An assembly for solar panels as claimed in any one of the preceding claims, further comprising bearing means provided between the frame and the cross member, wherein a portion of the frame extends to an opposite side of the bearing to act as a counterweight.

8. An assembly for solar panels as claimed in claim 7, wherein the bearing means are provided beneath the solar panels.

9. An assembly for solar panels as claimed in any one of the preceding claims, further comprising a battery for providing power to the control means and the means for rotating the frame, the control means further comprising a circuit for recharging the battery from the solar panels.

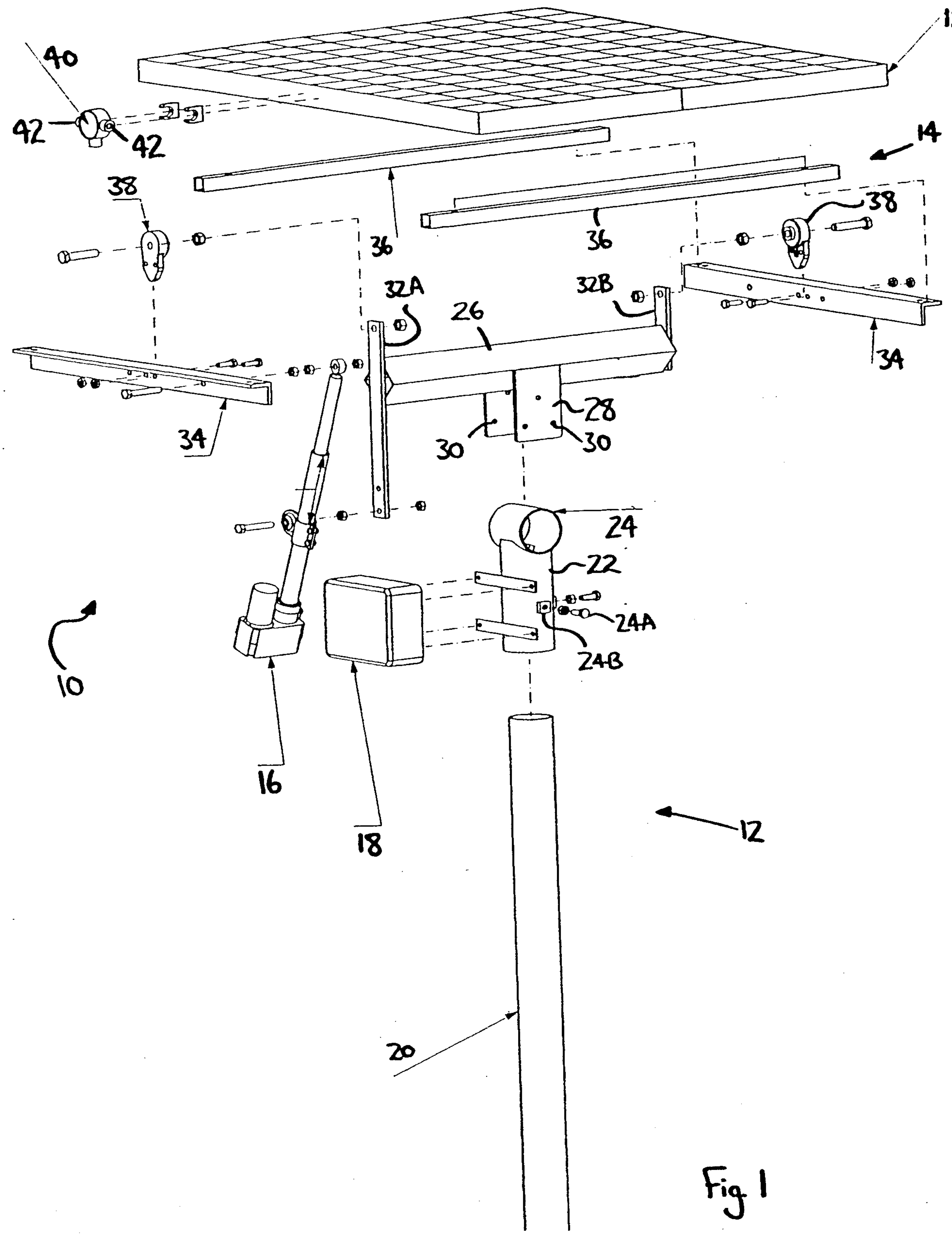
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Fig 1

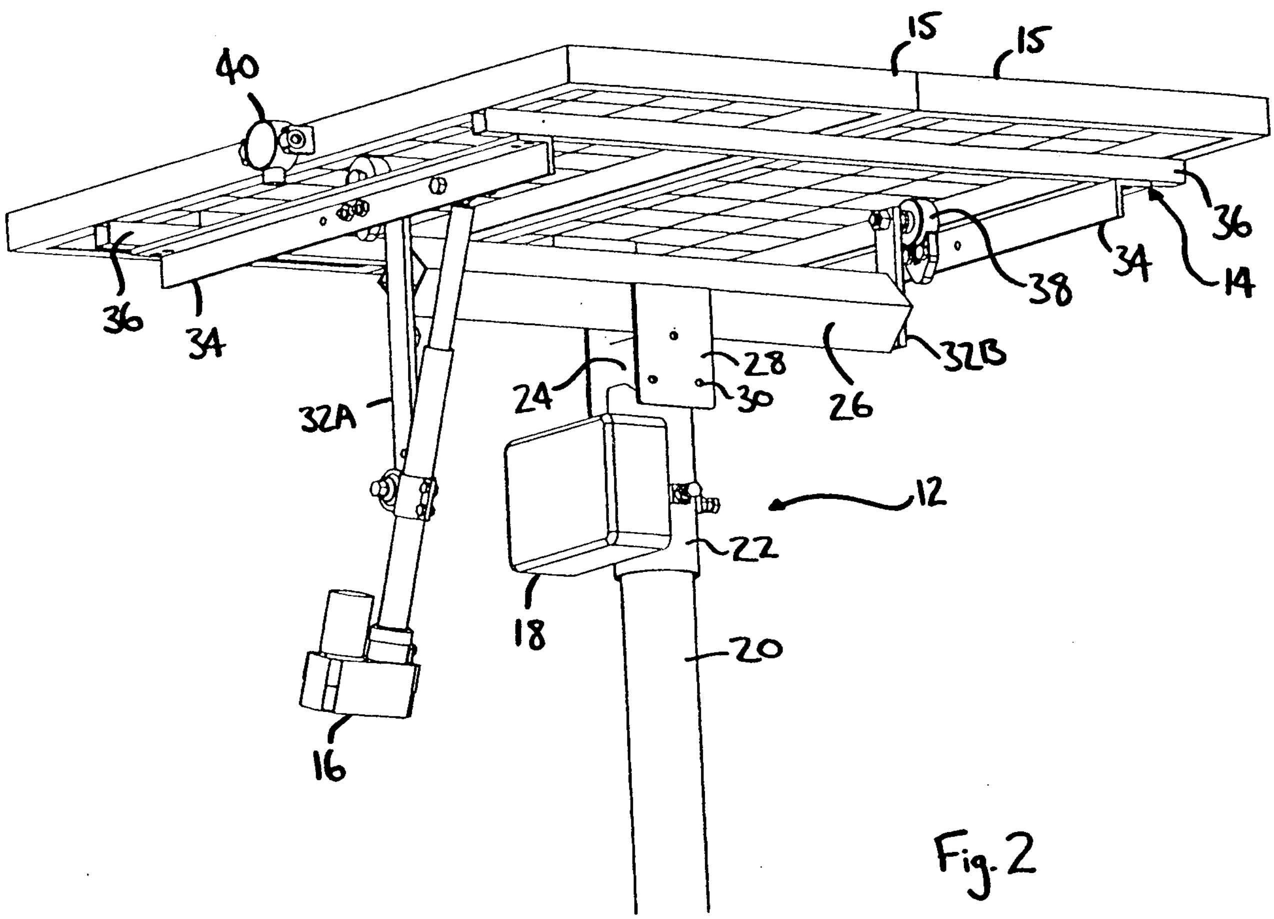
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Fig. 2

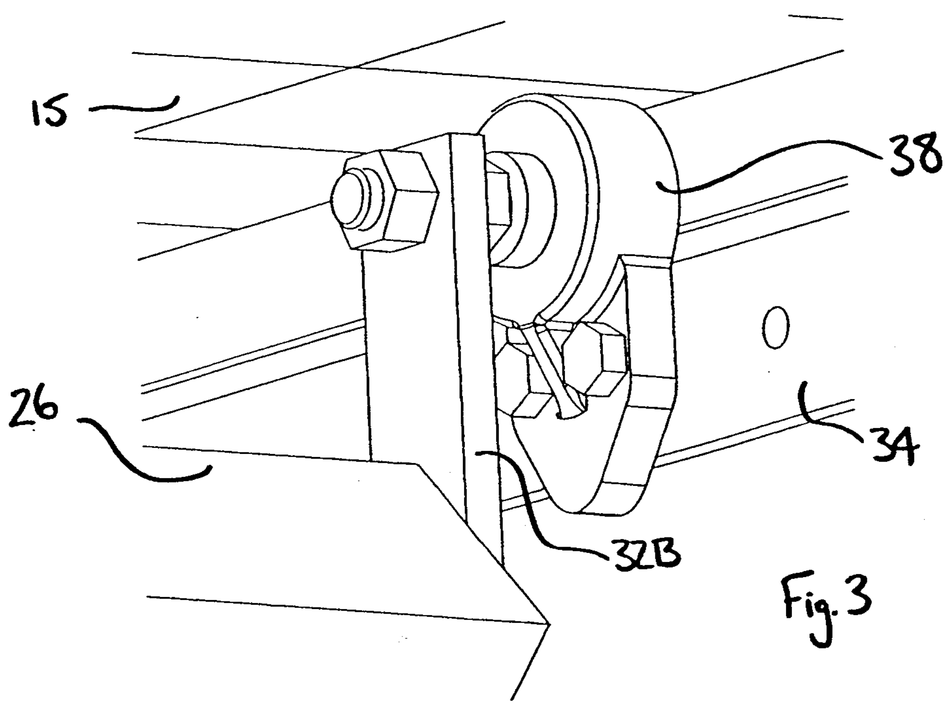
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Fig. 3

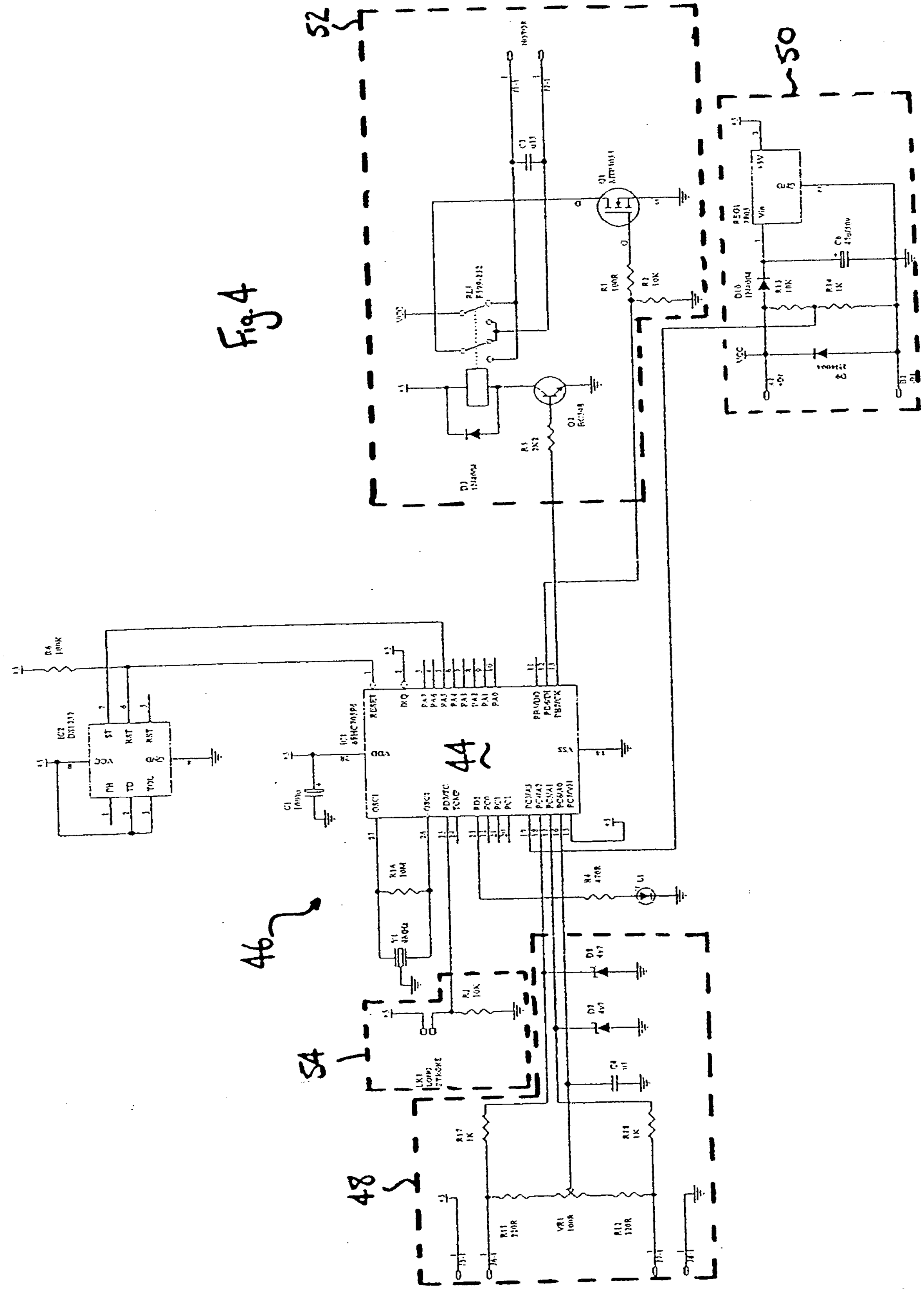



Fig. 4

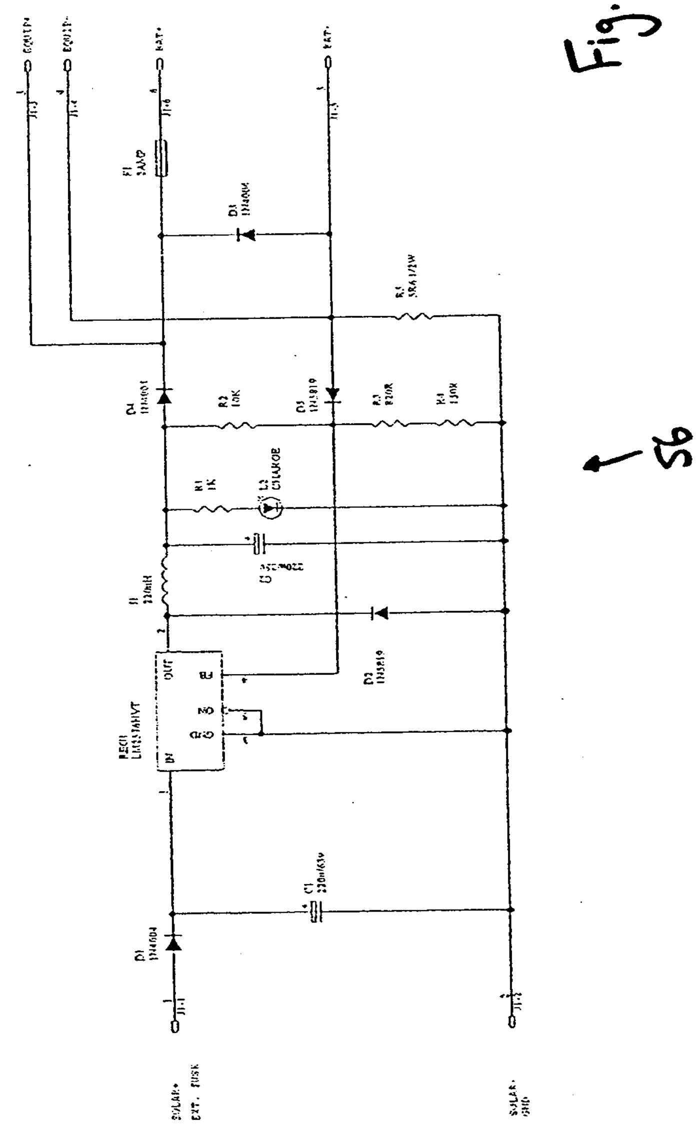



Fig. 5

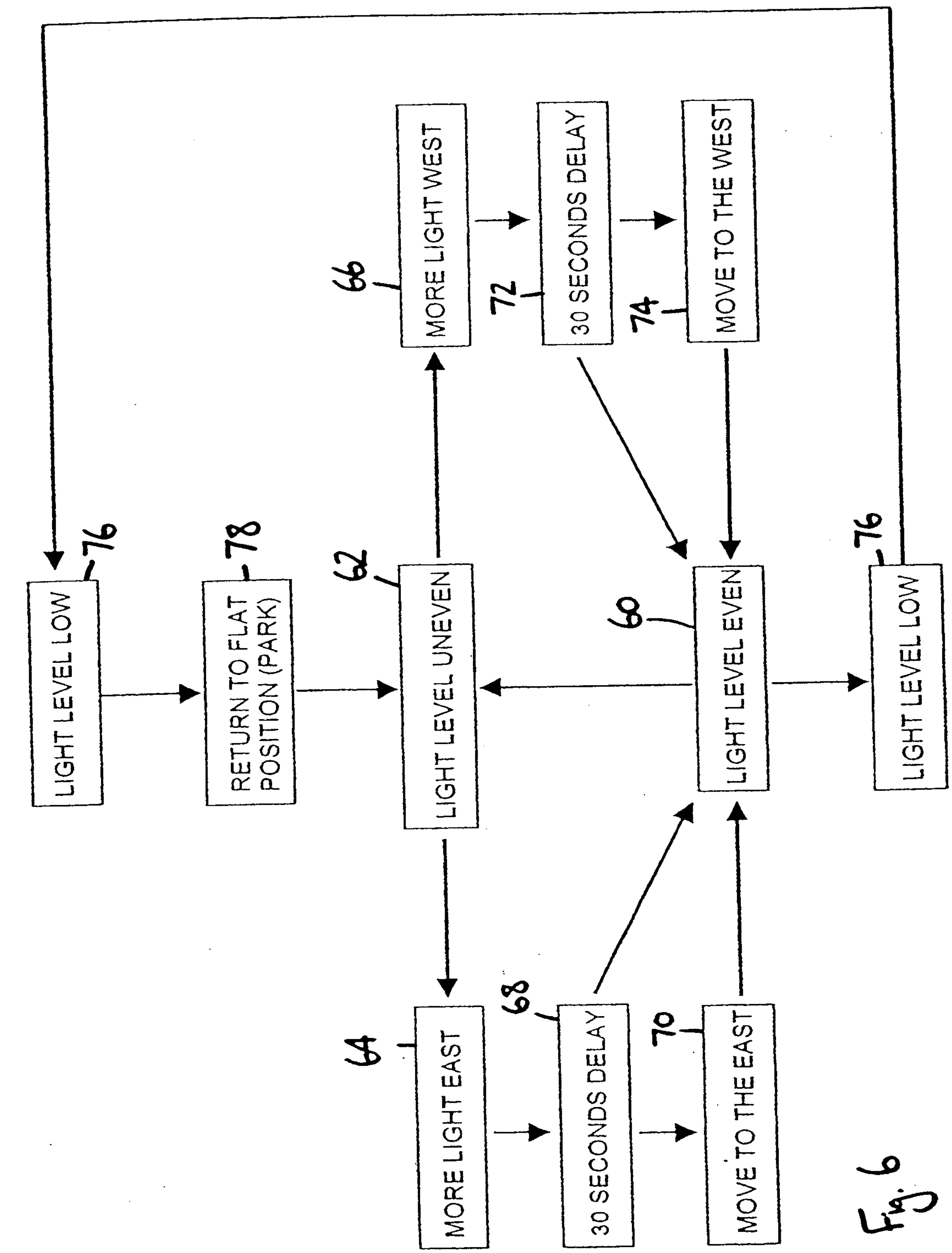
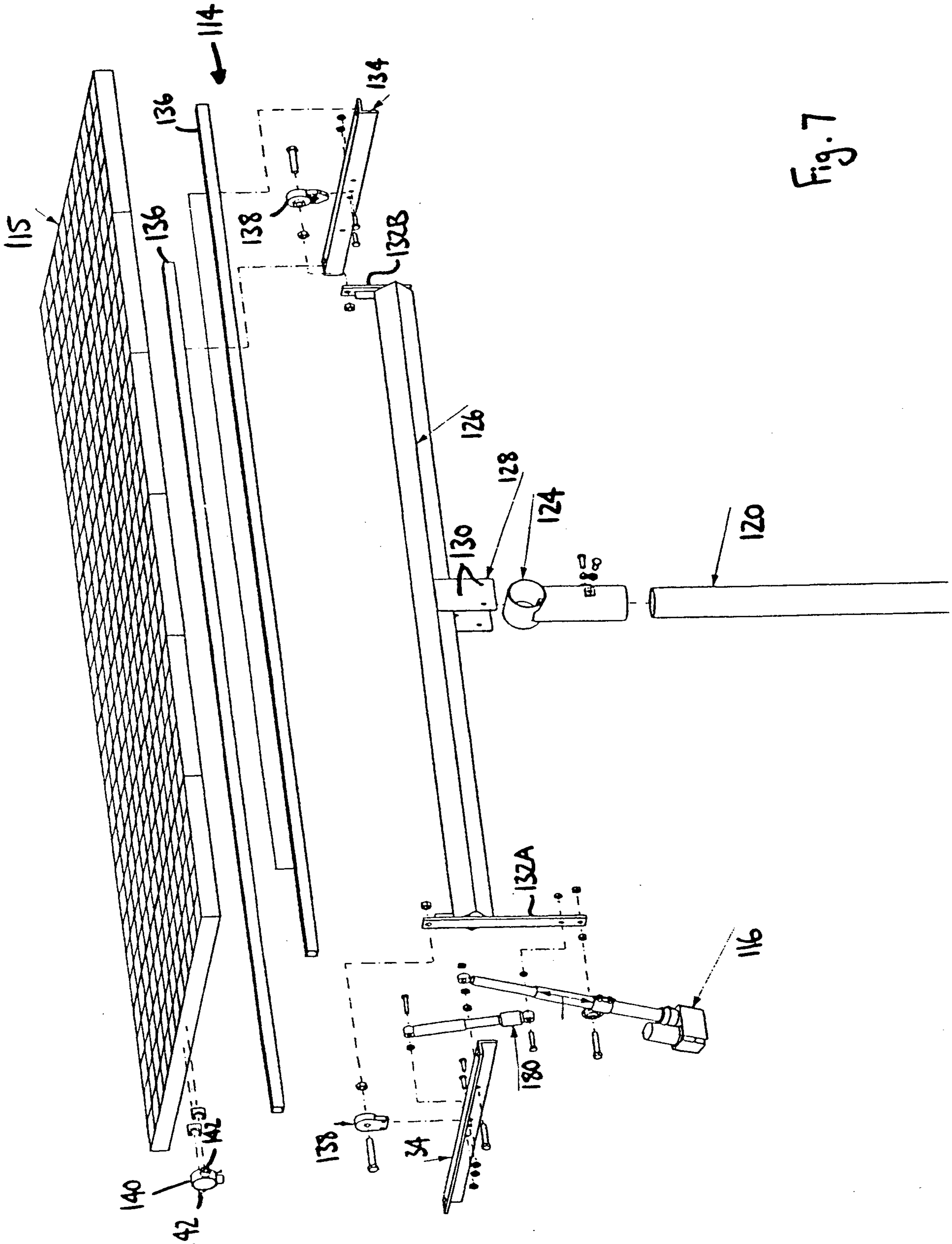

LIGHT LEVEL LOW
76
RETURN TO FLAT POSITION (PARK)
78
LIGHT LEVEL UNEVEN
62
MORE LIGHT WEST
66
30 SECONDS DELAY
72
MOVE TO THE WEST
74
LIGHT LEVEL EVEN
60
LIGHT LEVEL LOW
76
MORE LIGHT EAST
64
30 SECONDS DELAY
68
MOVE TO THE EAST
70

Fig. 6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132B
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132A
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Fig. 7

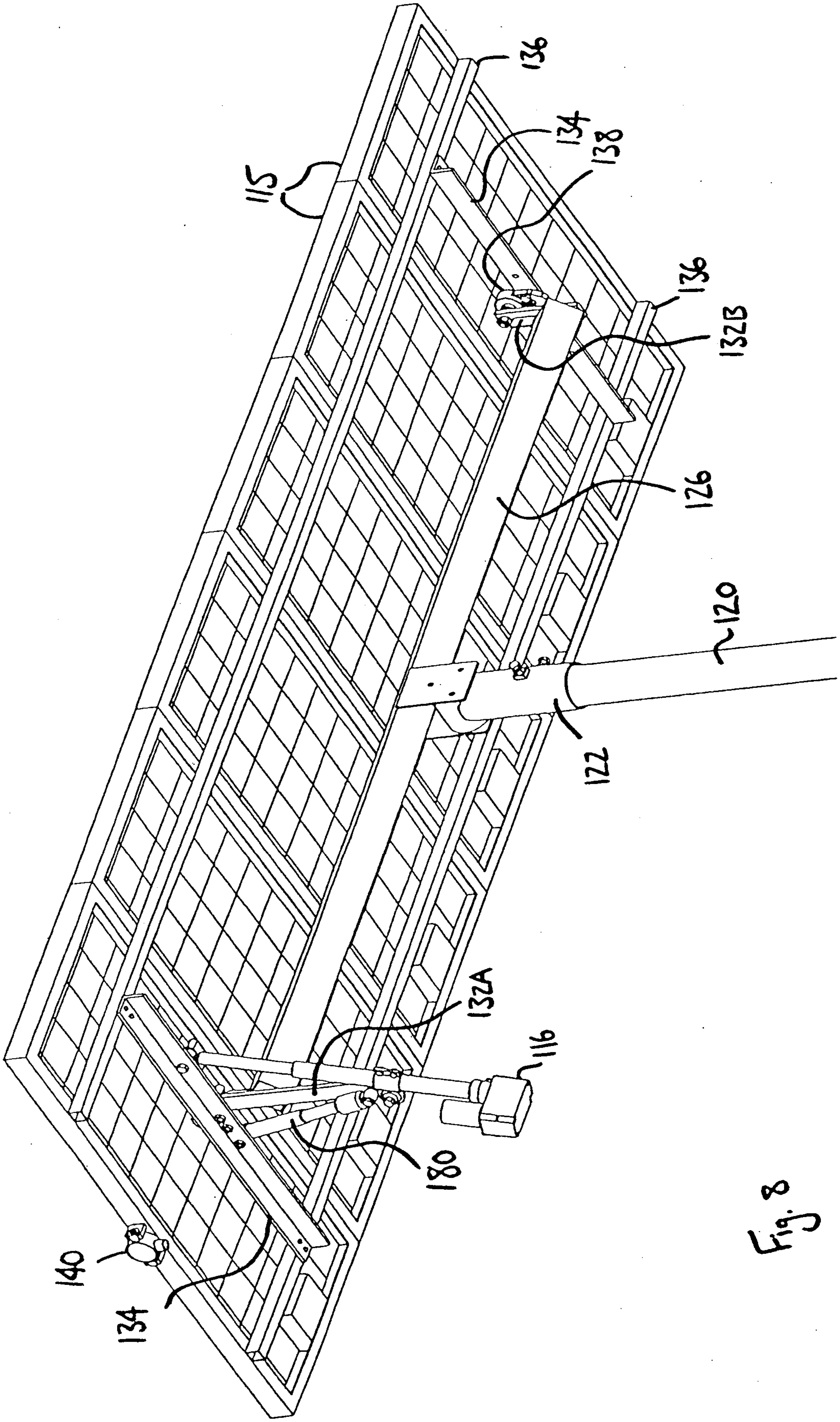
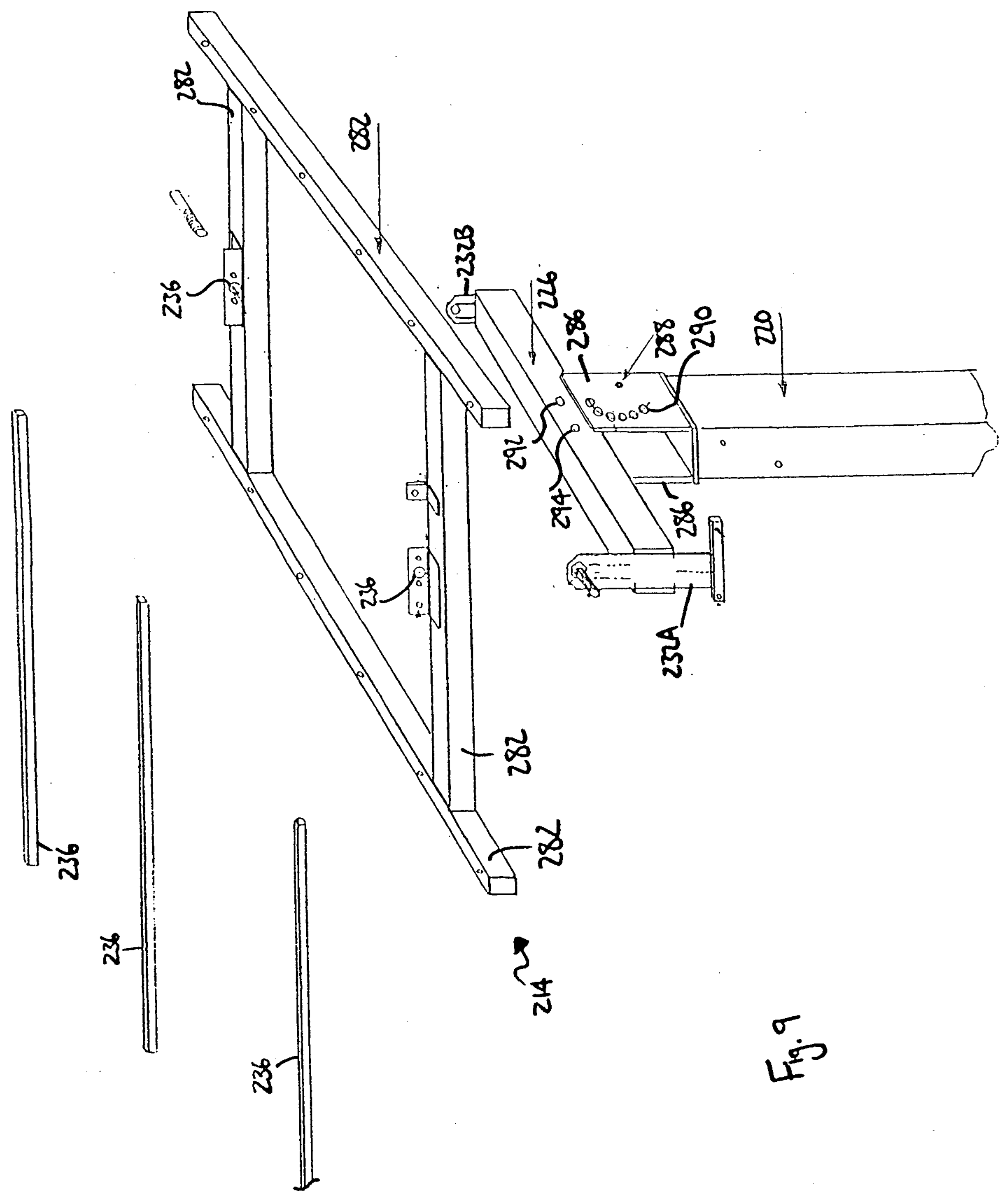



Fig. 8


282
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232A
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214

Fig. 9

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU 99/01030**

| **A.** | **CLASSIFICATION OF SUBJECT MATTER** |
|---|---|
| Int Cl$^{6}$: | F24J 2/38 |

According to International Patent Classification (IPC) or to both national classification and IPC

| **B.** | **FIELDS SEARCHED** |
|---|---|

Minimum documentation searched (classification system followed by classification symbols)
IPC : F24J 2/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

| **C.** | **DOCUMENTS CONSIDERED TO BE RELEVANT** |
|---|---|

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 95/00806 A1 (DE-VAPPA)<br>5 January 1995<br>See figures | 1-9 |
| X | AU 65939/94 A (POWER KINETICS)<br>11 January 1996<br>See figures | 1-9 |
| X | WO 94/28360 A1 (BERGER)<br>8 December 1994<br>See figures | 1-9 |

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" Document defining the general state of the art which is not considered to be of particular relevance
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 12 January 2000 | 02 FEB 2000 |

| Name and mailing address of the ISA/AU | Authorized officer |
|---|---|
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# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/AU 99/01030**

**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 97/49956 A1 (FINNIE)<br>31 December 1997<br>See figures | 1-9 |

## INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
**PCT/AU 99/01030**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | |
|---|---|---|---|
| WO | 95/00806 | AU | 43269/93 |
| AU | 65939/94 | NONE | |
| WO | 94/28360 | AU | 67934/94 |
| | | BR | 9406707 |
| | | EP | 706631 |
| | | US | 5730117 |
| | | DE | 4419244 |
| WO | 9749956 | AU | 32784/97 |

END OF ANNEX